fairy shrimp populations are regularly monitored by Bureau of Land Management staff. In the San Joaquin Vernal Pool Region, vernal pool habitats occupied by the longhorn fairy shrimp are protected at the Kesterson National Wildlife Refuge.

4. VERNAL POOL FAIRY SHRIMP (*BRANCHINECTA LYNCHI*)

a. Description and Taxonomy

Taxonomy.—The vernal pool fairy shrimp (*Branchinecta lynchi*) was first described by Eng, Belk and Eriksen (Eng *et al.* 1990). The species was named in honor of James B. Lynch, a systematist of North American fairy shrimp. The type specimen was collected in 1982 at Souza Ranch, Contra Costa County, California. Although not yet described, the vernal pool fairy shrimp had been collected as early as 1941, when it was identified as the Colorado fairy shrimp by Linder (1941).

Description and Identification.—Although most species of fairy shrimp look generally similar (see **Box 1**- Appearance and Identification of Vernal Pool Crustaceans), vernal pool fairy shrimp are characterized by the presence and size of several mounds (see identification section below) on the male's second antennae, and by the female's short, pyriform brood pouch. Vernal pool fairy shrimp vary in size, ranging from 11 to 25 millimeters (0.4 to 1.0 inch) in length (Eng *et al.* 1990). Vernal pool fairy shrimp closely resemble Colorado fairy shrimp (*Branchinecta coloradensis*) (Eng *et al.* 1990). However, there are differences in the shape of a small mound-like feature located at the base of the male's antennae, called the pulvillus. The Colorado fairy shrimp has a round pulvillus, while the vernal pool fairy shrimp's pulvillus is elongate. The vernal pool fairy shrimp can also be identified by the shape of a bulge on the distal, or more distant end, of the antennae. This bulge is smaller and less spiny on the vernal pool fairy shrimp. The female Colorado fairy shrimp's brood pouch is longer and more cylindrical than the vernal pool fairy shrimp's. Female vernal pool fairy shrimp also closely resemble female midvalley fairy shrimp. These two species can be distinguished by the number and placement of lobes on their backs, called dorsolateral thoracic protuberances. Vernal pool fairy shrimp have paired dorsolateral thoracic protuberances on the third thoracic segment that are lacking in the midvalley fairy shrimp (Belk and Fugate 2000).

b. Historical and Current Distribution

Historical Distribution.—The vernal pool fairy shrimp was identified relatively recently, in 1990, and there is little information on the historical range of the species. However, the vernal pool fairy shrimp is currently known to occur

in a wide range of vernal pool habitats in the southern and Central Valley areas of California, and in two vernal pool habitats within the "Agate Desert" area of Jackson County, Oregon. The vegetation and land use in its Oregon range are similar to those of northern California's inland valleys.

It is likely the historical distribution of this species coincides with the historical distribution of vernal pools in California's Central Valley and southern Oregon (**Figure II-37**). Holland (1978) estimated that roughly 1,618,700 hectares (4,000,000 acres) of vernal pool habitat existed in the Central Valley prior to the widespread agricultural development that began in the mid-1800s. He found that although the current and historical distribution of vernal pools is similar, vernal pools are now far more fragmented and isolated from each other than during historical times and currently occupy only about 25 percent of their former land area (Holland 1998). The current distribution of the vernal pool fairy shrimp in the Central Valley may be similar to its historical distribution in extent, but remaining populations are now considerably more fragmented and isolated than in pre-agricultural times.

The historical distribution of the vernal pool fairy shrimp in the Central Coast, Carrizo, and Santa Barbara Vernal Pool Regions is not known. The historical distribution of the vernal pool fairy shrimp in southern California may also have been similar to the historical distribution of its vernal pool habitat. Unlike the Central Valley, where vernal pool habitats were historically widespread, vernal pools in southern California were probably always limited in area and extent. Even so, vernal pool habitats in this area were once far more extensive than they are today (Bauder and McMillan 1998, Mattoni and Longcore 1998). In Los Angeles County, the coastal prairie and associated vernal pools may have historically occupied as much as 9,308 hectares (23,000 acres) (Mattoni *et al.* 1997). Vernal pools in San Diego County probably covered 51,800 hectares (128,000 acres) prior to intensive agriculture and urbanization (Bauder and McMillan 1998). The vernal pool fairy shrimp was likely historically present in available vernal pool habitats in Riverside, Los Angeles, Ventura, and Orange Counties. However, vernal pool fairy shrimp are currently absent from San Diego County, despite the presence of vernal pool habitats there. It is possible the vernal pool fairy shrimp is absent from the San Diego Vernal Pool Region as a result of competition with other species, such as the San Diego fairy shrimp. However, this hypothesis has not been formally tested.

Vernal pool habitats in the Agate Desert of southern Oregon historically occupied approximately 12,950 hectares (32,000 acres) (Oregon Natural Heritage Program 1997). The Agate Desert is located in the Rogue/Illinois River Valley region of the Klamath Mountains ecoregion. This area may have also constituted the historical range of the vernal pool fairy shrimp in this region. However, because

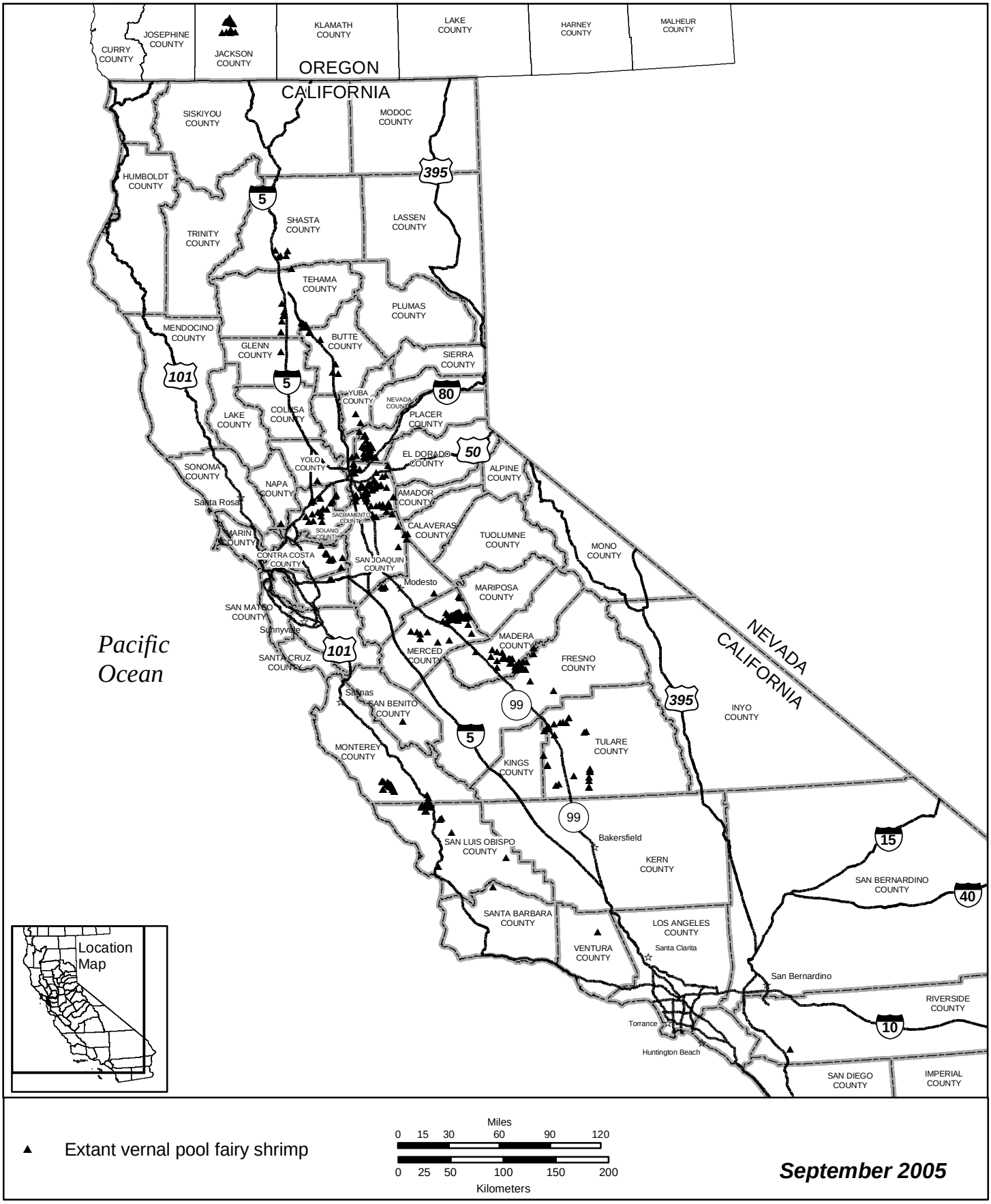

Figure II-37. Distribution of vernal pool fairy shrimp (*Branchinecta lynch*i).

the presence of vernal pool fairy shrimp was first documented in 1998, it is possible that additional locations for the species will be found in Oregon in the future.

Current Distribution.—The vernal pool fairy shrimp is currently found in 28 counties across the Central Valley and coast ranges of California, and in Jackson County of southern Oregon. The species occupies a variety of vernal pool habitats, and occurs in 11 of the 17 vernal pool regions identified in California (Keeler-Wolf *et.al*. 1998). Although the vernal pool fairy shrimp is distributed more widely than most other fairy shrimp species covered in this recovery plan, it is generally uncommon throughout its range, and rarely abundant where it does occur (Eng *et al.* 1990, Eriksen and Belk 1999). Helm (1998) found vernal pool fairy shrimp in only 16 percent of pools sampled across 27 counties, and Sugnet (1993) found this species in only 5 percent of 3,092 locations sampled.

The Agate Desert of southern Oregon comprises the northern extent of the range of the vernal pool fairy shrimp. Here, vernal pool fairy shrimp are known from the vernal pools within the Agate-Winlo soils of the Agate Desert landform and the Randcore-Shoat soils underlain by lava bedrock on top of Upper and Lower Table Rocks (Helm and Fields 1998). In California, the vernal pool fairy shrimp occurs on the Thomes Creek Ecological Reserve and the Stillwater Plains preservation bank in Tehama County, and at isolated locations in Glenn and Shasta Counties in the Northwestern Sacramento Valley Vernal Pool Region. In the Northeastern Sacramento Valley Vernal Pool Region, the species occurs in the vicinity of Vina plains and the City of Chico in Tehama and Butte Counties, respectively. The greatest number of known occurrences of the vernal pool fairy shrimp are found in the Southeastern Sacramento Vernal Pool Region, where it is found in scattered vernal pool habitats in Placer, Sacramento, and San Joaquin Counties, in the vicinity of Beale Air Force Base in Yuba County, and at a single location in El Dorado County. In the Solano-Colusa Vernal Pool Region, the vernal pool fairy shrimp is known from the vicinity of Jepson Prairie, and the cities of Vacaville and Dixon in Solano County. In the San Joaquin Valley Vernal Pool Region, the vernal pool fairy shrimp is found at the Grasslands Ecological Area in Merced County, at the Pixley National Wildlife Refuge in Tulare County, and at isolated locations in Kings and Stanislaus Counties. In the Southern Sierra Foothills Vernal Pool Region, the vernal pool fairy shrimp is known from the Stone Corral Ecological Reserve and the Hogwallow Preserve in Tulare County and from scattered locations on private land in Stanislaus, San Joaquin, Fresno, Madera, and Merced Counties.

The vernal pool fairy shrimp is also found in isolated patches along the central and southern Coast Range of California. In the Livermore Vernal Pool Region,

the vernal pool fairy shrimp has been found in the Springtown area and in the vicinity of Byron Airport in Alameda and Contra Costa Counties respectively. In the Central Coast region the species has been found in a minimum of 55 wetland pools at Fort Hunter Liggett in Monterey County; at two locations in San Benito County; and at one site 2.5 miles east of the City of Paso Robles. The vernal pool fairy shrimp occurs at a single location in Napa County in the Lake-Napa Vernal Pool Region. In the Carrizo Vernal Pool Region, the vernal pool fairy shrimp has been found in a minimum of 61 pools at Camp Roberts and in the vicinity of Soda Lake on the Carrizo Plain in San Luis Obispo County. In the Santa Barbara Vernal Pool Region, the vernal pool fairy shrimp has been found in Cachuma Canyon in Santa Barbara County, in the Carlsberg vernal pools in Ventura County, and in the Cruzan Mesa vernal pools in Los Angeles County. Vernal pool fairy shrimp have also been found at two locations within the Los Padres National Forest in Ventura County, outside the Santa Barbara Vernal Pool Region. In the Western Riverside County Vernal Pool Region, the species is known to occur at Skunk Hollow and on the Santa Rosa Plateau.

c. Life History and Habitat

Life History.—Vernal pool fairy shrimp are highly adapted to the environmental conditions of their ephemeral habitats. One adaptation is the ability of the vernal pool fairy shrimp eggs, or cysts, to remain dormant in the soil when their vernal pool habitats are dry. Another important adaptation is that the vernal pool fairy shrimp has a relatively short life span, allowing it to hatch, mature to adulthood, and reproduce during the short time period when vernal pools contain water. The vernal pool fairy shrimp can reach sexual maturity in as few as 18 days at optimal conditions of 20 degrees Celsius (68 degrees Fahrenheit), and can complete its life cycle in as little as 9 weeks (Gallagher 1996, Helm 1998). However, maturation and reproduction rates of vernal pool crustaceans are controlled by water temperature and can vary greatly (Eriksen and Brown 1980, Helm 1998). Helm (1998) observed that vernal pool fairy shrimp did not reach maturity until 41 days at water temperatures of 15 degrees Celsius (59 degrees Fahrenheit). Helm (1998) observed six separate hatches of vernal pool fairy shrimp in a single pool within a single wet season, and Gallagher (1996) observed three separate hatches of vernal pool fairy shrimp in vernal pools in Butte County. Helm (1998) found the mean life span of the vernal pool fairy shrimp was significantly shorter than the California fairy shrimp, but not significantly different from midvalley, longhorn, or Conservancy fairy shrimp observed under the same conditions. In larger pools that hold water for longer durations, vernal pool fairy shrimp are capable of hatching multiple times if water temperatures drop to below 10 degrees Celsius (50 degrees Fahrenheit), a necessary environmental cue for vernal pool fairy shrimp cyst hatching

(Gallagher 1996, Helm 1998). Helm (1998) observed vernal pool fairy shrimp living for as long as 147 days.

Habitat.—Vernal pool fairy shrimp exist only in vernal pools or vernal pool-like habitats. Individuals have never been found in riverine, marine, or other permanent bodies of water. Vernal pool habitats form in depressions above an impervious soil layer or duripan. Due to local topography and geology, the depressions are part of an undulating landscape, where soil mounds are interspersed with basins, swales, and drainages. Water movement within complexes allows vernal pool fairy shrimp to move between individual pools. These movement patterns, as well as genetic evidence, indicate that vernal pool fairy shrimp populations exist within and are defined by entire vernal pool complexes, rather than individual vernal pools (Simovich *et al.* 1992, King, *et al.* 1996).

The vernal pool fairy shrimp occupies a variety of different vernal pool habitats, from small, clear, sandstone rock pools to large, turbid, alkaline, grassland valley floor pools (Eng *et al.* 1990, Helm 1998). Although the vernal pool fairy shrimp has been collected from large vernal pools, including one exceeding 10 hectares (25 acres) in area (Eriksen and Belk 1999), it tends to occur primarily in smaller pools (Platenkamp1998), and is most frequently found in pools measuring less than 0.02 hectare (0.05 acre) in area (Gallagher 1996, Helm 1998). The vernal pool fairy shrimp typically occurs at elevations from 10 meters (33 feet) to 1,220 meters (4,003 feet) (Eng *et al.* 1990), although two sites in the Los Padres National Forest have been found to contain the species at an elevation of 1,700 meters (5,600 feet). The vernal pool fairy shrimp has been collected at water temperatures as low as 4.5 degrees Celsius (40 degrees Fahrenheit) (Eriksen and Belk 1999), and has not been found in water temperatures above about 23 degrees Celsius (73 degrees Fahrenheit) (Helm 1998, Eriksen and Belk 1999). The species is typically found in pools with low to moderate amounts of salinity or total dissolved solids (Collie and Lathrop 1976, Keeley 1984, Syrdahl 1993). Vernal pools are mostly rain fed, resulting in low nutrient levels and dramatic daily fluctuations in pH, dissolved oxygen, and carbon dioxide (Keeley and Zedler 1998). Although there are many observations of the environmental conditions where vernal pool fairy shrimp have been found, there have been no experimental studies investigating the specific habitat requirements of this species. Platenkamp (1998) found no significant differences in vernal pool fairy shrimp distribution between four different geomorphic surfaces studied at Beale Air Force Base.

In Oregon, the vernal pool fairy shrimp is found in two distinct vernal pool habitats (Helm and Fields 1998). The species occurs on alluvial fan terraces associated with Agate-Winlo soils on the Agate Desert, and in the Table Rocks

area on Randcore-Shoat soils underlain by lava bedrock. These vernal pool habitats represent the northern extent of Mediterranean vernal pools addressed in this recovery plan, and the northern extent of the range of the vernal pool fairy shrimp.

In the Western Riverside County and Santa Barbara vernal pool regions, the vernal pool fairy shrimp occurs on inland mesas and valleys, on weak to strongly alkaline soils. In the Los Padres National Forest in Ventura County, it is known to occur in atypical habitats that consist of vernal pools located under a *Pinus jeffreyi* (Jeffrey pine)canopy that does not possess a grass understory.

Community Associations.—The vernal pool fairy shrimp occupies the same vernal pool habitats as many of the other species addressed in this recovery plan. Plant species that have been found in the same vernal pool habitats as the vernal pool fairy shrimp include *Astragalus tener* var. *tener, Atriplex persistens, Castilleja campestris* ssp. *succulenta, Chamaesyce hooveri, Eryngium spinosepalum, Gratiola heterosepala, Legenere limosa, Limnanthes floccosa* ssp. *californica, Neostapfia colusana*, all of the *Orcuttia* species, and *Tuctoria greenei*. In Oregon, the vernal pool fairy shrimp is found in the same vernal pool habitats as two listed vernal pool plants, *Lomatium cookii* (Cook's lomatium) and *Limnanthes floccosa* ssp. *grandiflora* (large-flowered woolly meadowfoam). The vernal pool fairy shrimp occupies the same vernal pool habitats as the delta green ground beetle.

The vernal pool fairy shrimp has been found in the same vernal pool habitats as all of the other vernal pool crustaceans described in this recovery plan: the vernal pool tadpole shrimp, California fairy shrimp, the Conservancy fairy shrimp, the longhorn fairy shrimp, and the midvalley fairy shrimp. In Southern California, vernal pool fairy shrimp have been found to co-occur with the Riverside fairy shrimp (*Streptocephalus woottoni*), federally listed as endangered . However, the vernal pool fairy shrimp has rarely been collected from the same pools as other fairy shrimp species (Eng *et al.* 1990, Maeda-Martinez *et al.* 1997, Eriksen and Belk 1999). When coexistence does occur, it has been in longer lived pools, and the vernal pool fairy shrimp are often less abundant than other fairy shrimp species (Eng *et al.* 1990, Gallagher 1996, Eriksen and Belk 1999). Given the apparently wide distribution of this species and its tolerance for a wide range of conditions, it is possible that the absence of the vernal pool fairy shrimp in certain habitats is explained by competitive exclusion by other fairy shrimp (Helm 1998, Eriksen and Belk 1999). Vernal pool tadpole shrimp are predators of vernal pool fairy shrimp, whereas vernal pool fairy shrimp feed on algae, bacteria, protozoa, rotifers, and bits of detritus.

The vernal pool fairy shrimp occurs in the same vernal pool habitats as the California tiger salamander (*Ambystoma californiense*; federally listed as threatened or endangered, depending upon the subject population) and the western spadefoot toad, a species of concern. Vernal pool fairy shrimp provide an important food source for a number of species, including the western spadefoot toad (Simovich *et al.* 1991). Vernal pool fairy shrimp are also a major prey item for waterfowl, such as ducks (Proctor *et al.* 1967, Krapu 1974, Swanson *et al.* 1974, Silveira 1996). In turn, waterfowl and other migratory birds are important dispersal agents for this and other vernal pool species.

d. Reasons for Decline and Threats to Survival

Most species addressed in this recovery plan are threatened by similar factors because they occupy the same vernal pool ecosystems. These general threats, faced by all the covered species, are discussed in greater detail in the Introduction section of this recovery plan. Additional, specific threats to vernal pool fairy shrimp are described below.

As the California Natural Diversity Database (2003) indicates, 92 occurrences (27 percent) of vernal pool fairy shrimp are threatened by development, and an additional 27 occurrences (7 percent) are threatened by agricultural conversion.

In the Carrizo Vernal Pool Region, vernal pool habitats known to contain the vernal pool fairy shrimp are currently located on Federal land at the Camp Roberts Military Base and at the Carrizo National Monument. Although these areas are not immediately threatened by development, Camp Roberts may be threatened by military activities that alter historical vernal pools characteristics and introduce nonnative plant species. In two of the three plots that were fenced to protect vernal pools from training activities on Camp Roberts, nonnative *Taeniatherum caput-medusae* became more prolific and threatened to diminish the pool area available to fairy shrimp because nonnative plants encroached on pool edges.

In the Central Coast region, the vernal pool fairy shrimp is known only from Federal land on the Fort Hunter Liggett Military Reservation. Training and maintenance activities on this military base also have the potential to degrade some historical wetland habitats that are inhabited by fairy shrimp. In the Livermore Vernal Pool Region, the vernal pool fairy shrimp is located primarily on private land, where it is threatened by development, including expansion of the Byron Airport.

In the Northeastern Sacramento Valley Vernal Pool Region, most of the known occurrences of the vernal pool fairy shrimp are located on Caltrans rights-of-way

and are thus threatened by various future road improvement projects in this region, particularly the future expansion of Highway 99. Additional populations are threatened by commercial and residential development projects. Some occurrences on private land in the Northwestern Sacramento Vernal Pool Region may be threatened by agricultural conversion or development. In the Southeastern Sacramento Vernal Pool Region, the vernal pool fairy shrimp is threatened by urban development. Both Sacramento and Placer Counties are currently developing Habitat Conservation Plans to address growth in the region.

In the San Joaquin Valley region, the vernal pool fairy shrimp is found primarily on private land where it is threatened by direct habitat loss, including urban development and agricultural conversion.

Refer to the Draft Santa Rosa Plains Recovery Plan (in development) for information regarding threats facing the vernal pool fairy shrimp in the Santa Rosa Vernal Pool Region, as identified by Keeler-Wolf *et .al*. (1998).

In the Solano-Colusa region, the vernal pool fairy shrimp is threatened by development on the private property where it occurs.

In the Southern Sierra Foothills region, the species is threatened by the proposed University of California, Merced campus, which will likely also contribute to significant growth in the region, resulting in additional loss of vernal pool crustacean habitat. Agricultural conversion and flood control projects on Bureau of Reclamation land also threaten the species in this region.

In the Western Riverside County region, vernal pool fairy shrimp populations are threatened by development where they occur on private land in Los Angeles, Ventura, and Riverside Counties. Although other populations in Riverside County are protected at the Santa Rosa Plateau managed by the Nature Conservancy, these habitats may be threatened by the development of adjacent lands (Chester 2000).

In Oregon, vernal pool fairy shrimp occurring on the Agate Desert are threatened by commercial and industrial development, agricultural conversion, and utility projects (Oregon Natural Heritage Program 1997). Over 40 percent of the vernal pool habitats remaining in Oregon have been degraded (Borgias and Patterson 1999). Vernal pool habitats that are protected on the Agate Desert by the Nature Conservancy are threatened by the indirect effects of adjacent land use, including alteration of hydrology (Evans 2000). Vernal pool fairy shrimp populations on the Table Rocks area managed by the Bureau of Land Management are also threatened by direct influences of incompatible land uses. Because the portion of the Table Rocks managed by the Bureau of Land Management is an Area of

Critical Environmental Concern, the pools on land administered by the Bureau of Land Management are in an area that is not available for timber harvest and closed to off-highway vehicle use. Grazing is allowed for 1 month in the spring on Upper Table Rock only. The area is open to mineral entry. There is a single access road to the summit of each of the Table Rocks from adjacent private lands, and an old airplane landing strip is present on Lower Table Rock. The tops of the Table Rocks are closed to motorized vehicles, including aircraft. Threats to the vernal pools on the Table Rocks are primarily a result of recreational use: human trampling in the wet areas near pools and potential change in subsurface or surface flow runoff patterns due to trail construction and/or improvement. The Bureau of Land Management is scheduled to begin development of a management plan for Upper and Lower Table Rocks in 2004.

e. Conservation Efforts

On September 19, 1994, the final rule to list the vernal pool fairy shrimp as threatened was published in the *Federal Register* (U.S. Fish and Wildlife Service 1994*a)*. In 2005, critical habitat was designated for the vernal pool fairy shrimp and several other vernal pool species in *Final Designation of Critical Habitat for Four Vernal Pool Crustaceans and Eleven Vernal Pool Plants in California and Southern Oregon; Evaluation of Economic Exclusions From August 2003 Final Designation; Final Rule* (U.S. Fish and Wildlife Service 2005).

Conservation efforts for the vernal pool fairy shrimp are divided into five broad categorie: regulatory and legal protections, education and outreach, research, conservation planning and habitat protection, and species specific management and monitoring. A brief description of each type of conservation action is provided below.

Regulatory and Legal Protections. The vernal pool fairy shrimp is protected as a threatened species under the Endangered Species Act. The International Union for the Conservation of Nature listed the vernal pool fairy shrimp as vulnerable in the 1996 Red List.

Education and Outreach: The Inland Invertebrate Working group distributes a newsletter devoted to fairy shrimp, the Anostracan News, and works toward disseminating information about the species. In 1998, we published a recovery plan for the vernal pools of Southern California (U.S. Fish and Wildlife Service 1998*b*).

Research: Vernal pool habitats have been the focus of much research, and scientific interest in this unique habitat type has continued to grow. Although there are numerous anecdotal accounts of the habitat requirements of the vernal

pool fairy shrimp, little specific information about the conservation needs of the species has been accumulated.

Conservation Planning and Habitat Protection: Approximately 5,261 hectares (13,000 acres) of vernal pool habitats, including mitigation banks, have been set aside for the vernal pool fairy shrimp specifically as terms and conditions of section 7 consultations. These areas are scattered throughout the Central Valley and represent important building blocks toward recovery of the vernal pool fairy shrimp.

Vernal pool habitats supporting populations of vernal pool fairy shrimp have been protected through a variety of other means. Within the Carrizo Vernal Pool Region, some of the vernal pool fairy shrimp habitat is protected from training and maintenance activities on the Camp Roberts military base.

In the Central Coast region, some of the vernal pools inhabited by fairy shrimp are protected at the Fort Hunter Liggett Military Reservation. In the Livermore Vernal Pool Region, the species occurs on public land in Contra Costa County and in the City of Livermore.

In the Northeastern Sacramento Valley region, vernal pool fairy shrimp are protected on a private mitigation area and on land owned by the Nature Conservancy. Private mitigation lands, the Stillwater Preservation Bank, and the Thomes Creek Ecological Reserve protect the species from direct habitat loss in the Northwestern Sacramento Valley Vernal Pool Region.

In the San Joaquin Valley Vernal Pool Region, vernal pool fairy shrimp are protected at the Grasslands Ecological Area, including Federal and State wildlife refuges in Merced County. In the Solano-Colusa Vernal Pool Region, the vernal pool fairy shrimp is protected on several preserves in the Jepson Prairie area and at Travis Air Force Base in Solano County. Several Habitat Conservation Plans are developing vernal pool preserve plans in the region, including Solano and Yolo Counties.

In the Southeastern Sacramento Valley Vernal Pool Region, vernal pool fairy shrimp occurrences are protected from development at a number of private mitigation areas, mitigation banks, and on the Cosumnes River Preserve's Valensin Ranch property. They also occur on the Howard Ranch, owned by a private rancher but protected by a conservation easement (J. Marty pers. comm. 2004). The species is also protected at Beale Air Force Base in Yuba County, where management and monitoring have recently been implemented (Jones and Stokes 1997). Several Habitat Conservation Plans are developing vernal pool preserve plans in the region, including Sacramento and Placer Counties.

In the Southern Sierra Foothills Vernal Pool Region, the species is protected at the Stone Corral Ecological Reserve. The California Department of Fish and Game recently implemented a 3-year grazing lease on the Stone Corral Ecological Reserve to reduce competitive exclusion of native vernal pool plant species by exotic weeds and invasive native (e.g., *Eleocharis* spp.) plant species, and to enhance the upland native plant species needed by native pollinators. They will be monitoring the Stone Corral Ecological Reserve in conjunction with the grazing lease. The California Department of Fish and Game has also initiated a preliminary sampling program for vernal pool invertebrates on several of the southern San Joaquin Valley California Department of Fish and Game preserves, including the Big Table Mountain Preserve and Stone Corral Ecological Reserve.

In the Western Riverside County Vernal Pool Region, vernal pool fairy shrimp are protected at the Santa Rosa Plateau Preserve, managed by The Nature Conservancy. The Recovery Plan for Vernal Pools of Southern California (U.S. Fish and Wildlife Service 1998b) includes vernal pool habitats containing vernal pool fairy shrimp populations as part of the Riverside Management Area, and establishes recovery strategies and criteria for protecting these habitats. Some of these habitats are also protected through a Habitat Conservation Plan.

In the Santa Barbara Vernal Pool Region, the Recovery Plan for Vernal Pools of Southern California (U.S. Fish and Wildlife Service 1998b) includes habitats containing vernal pool fairy shrimp populations in Los Angeles and Ventura Counties in the Transverse Management area. The recovery plan develops recovery strategies and criteria for listed fairy shrimp species occurring in these habitats. The three known vernal pools that support fairy shrimp on the Los Angles National Forest receive some protection as a result of section 7 consultation requirements that are mandatory for Federal agencies, and additional survey efforts would likely result in local range extensions within the National Forest.

In Oregon, vernal pool fairy shrimp populations are protected on The Nature Conservancy's Agate Desert and Whetstone Savanna preserves, containing approximately 78 hectares (197 acres) of vernal pool habitat. Habitat is also protected from development on property owned by the Bureau of Land Management (129 hectares [320 acres] of vernal pool habitat) and Bureau of Reclamation (60 hectares [150 acres] of vernal pool habitat). The Bureau of Land Management is scheduled to begin development of a management plan for Upper and Lower Table Rock in 2004. The Bureau of Reclamation is scheduled to begin development of a management plan for vernal pool habitat in 2005. A Wetland Conservation Plan is currently being developed to protect vernal pool habitats in the White City region of the Agate Desert.

Site-specific details of the recovery actions for vernal pool fairy shrimp populations in Oregon will be identified as part of a recovery plan for species of the upper Rogue River Valley, which is currently in preparation at our Roseburg Field Office. The Rogue River Valley recovery plan will develop an integrated, ecosystem-based strategy for recovery of vernal pool fairy shrimp and two endangered plant species that are endemic to the area, within the context of the broader recovery strategy identified in this Recovery Plan for Vernal Pool Ecosystems of California and Southern Oregon.

5. VERNAL POOL TADPOLE SHRIMP *(LEPIDURUS PACKARDI)*

a. Description and Taxonomy

Taxonomy.—The vernal pool tadpole shrimp was initially described by Simon (1886) and named *Lepidurus packardi*. Linder (1952) maintained *L. packardi* as a valid species. However, in a review of the order Notostraca, Longhurst (1955) reduced this and 18 other species to subspecies of *L. apus* based primarily on the lack of apparent geographic boundaries between *L. apus* and *L. packardi* populations. Lynch (1972) resurrected *L. packardi* to full species status based on further examination of specimens. This is the currently accepted taxonomic status of the vernal pool tadpole shrimp. Recent genetic analysis indicates *L. packardi* is a valid species (King and Hanner 1998).

Description and Identification.—Vernal pool tadpole shrimp, like other members of the Order Notostraca, are known as living fossils because they have changed little in appearance over roughly the last 2 million years, and resemble species found in the fossil record (Longhurst 1955, King and Hanner 1998). Vernal pool tadpole shrimp are distinguished by a large, shield-like carapace, or shell, that covers the anterior half of their body. Vernal pool tadpole shrimp have 30 to 35 pairs of phyllopods, a segmented abdomen, paired cercopods or tail-like appendages, and fused eyes. Mature vernal pool tadpole shrimp range in size from 15 to 86 millimeters (0.6 to 3.3 inches) in length.

Vernal pool tadpole shrimp and other species in the Order Notostraca have remained generally similar in appearance for hundreds of millions of years (Longhurst 1955). However, individuals often vary greatly in appearance, making classification and identification of species difficult (Gurney 1924, Linder 1952, Longhurst 1955, King and Hanner 1998). Recent genetic studies (King and Hanner 1998) may provide the basis for relating genetically detected differences to morphological variation, potentially allowing for the development of a classification key to the genus. Species in the genus *Lepidurus* can be distinguished from members of the similar looking genus *Triops* by the presence of a supra-anal plate between their cercopods, which is lacking in *Triops*. Two